T5 – RESISTANCE THERMOMETERS FOR WELDING-IN

Resistance thermometers for welding-in are intended for installation in protection sleeves, of various constructions, and for measuring temperature of liquid and gaseous media, at high pressures, primarily in tanks, pipelines, etc.

Resistance thermometer is installed directly in the existing protection sleeve or is delivered in a set with a protection sleeve, upon customer request.

Electrical connection is made via terminal block or a transmitter in the connection head.

Basic parts of resistance thermometer are as follows:

- connection head,
- neck tube,
- measuring insert.

Connection head of resistance thermometer can be of various dimensions and shapes and is defined via the configurator.

Measuring insert can be in classic and mantel design with different types of resistance sensor koji se which are defined via the configurator.

We recommend the mantel design, which has a few advantages:

- connection of the sensor and the lines is in highly compressed magnesium oxide, without the presence of oxygen,
- faster response,
- great resistance to vibrations,
- higher reliability in operation,
- longer service life.

The only advantage of the classic measuring insert is the lower price.

Technical characteristics

Basic technical characteristics are specified in the configurator.
By filling in the configurator, an order code is generated, which defines the product.

Installation length of resistance thermometer can be:

- constant (achieved by means of a process connection that is welded to neck tube),
- adjustable (achieved by means of a compression connection, which is movable along neck tube).

Process connections can be of different shapes and dimensions, upon customer request.

***Use*:**

- chemical industry,
- petroleum industry,
- power plants,
- food industry,
- pharmaceutical industry,
- construction machines, plants, containers...

Functionality and structure:

Measurement principle
The resistance sensor has an electrical resistance of 100Ω to 0°C. It is commonly known as a Pt sensor in line with the IEC 60751 standard. This resistance value increases with temperature, which is related to the characteristics of the resistor material (platinum). These types of sensors are called elements of positive temperature coefficient (PTC). The coefficient is fixed at α=0.00385°C¹, calculated between 0°C and 100°C, according to ITS90 (International Temperature Scale of 1990). Two types of platinum resistance thermometers are generally used:

- with wire wound (WW) which consists of a thin wire of high-purity platinum, double-wound inside a ceramic case. The ends of the case are closed with ceramic mass. The measurements obtained with these resistance thermometers are not only repeatable, but also show long-term thermal resistance / stability of the temperature characteristic in the temperature measurement range up to 600°C. This type of sensor is relatively large and is not resistant to vibrations.

- thin-filmed platinum resistance thermometers (TF) consisting of a precise amount of platinum applied, in a thickness of 1µ, by evaporation under vacuum, on a ceramic base. The platinum film is then structured to form a resistance trace, using either a lithographic process or a laser beam, and then calibrated with a laser. Then a layer of glass with a thickness of 10 to 15 µ is placed to protect the platinum. The connection wires are welded, to establish an electrical connection with the resistance trace and to secure the glass shell.

Common characteristics for all thin-filmed sensors are fast response, low thermal mass, i.e. smaller dimensions and significantly increased resistance to vibrations. Temperature changes in the resistance of such a sensor cause the desired temperature that is relevant to the change in resistance. The resistance characteristic at higher temperatures differs from that of standard, (WW) resistance sensors, so these resistors are used to measure temperatures up to 500°C.

Constituent parts – Thermometer structure
Basic parts of the **Group T5** resistance thermometer is given in Figure 1.

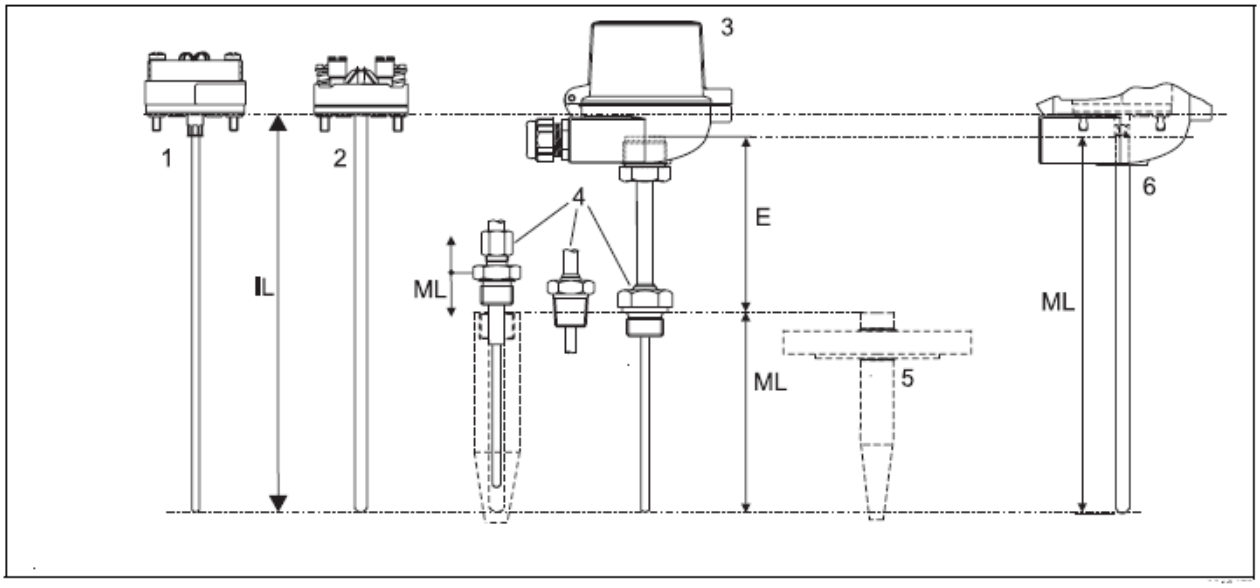


Figure 1 – Basic parts of the Group T5 resistance thermometer

1 -	Insert with transmitter installed	6 -	Variant without neck tube in case the protection sleeve and neck tube already exist in the process
2 -	Insert with ceramic block installed	Lv -	Length of the neck part of the tube
3 -	Connection head	Lu -	Installation length when there are components (sleeve and neck tube)
4 -	Connection to protection sleeve. Wound connection or compression fitting on neck tube	L -	Total length of the insert
5 -	Existing protection sleeve		

The structure of the **Group T5** resistance thermometer is modular (detachable). The connection head serves as a connection part for the mechanical and electrical connection of the measuring insert. Pt 100 sensors are protected inside the measuring insert. If installed in an existing protection sleeve, the insert can be replaced and calibrated even during the process. Ceramic blocks or transmitters can be installed on the measuring insert and are in the case of the connection head.

The **GroupT5** resistance thermometer is designed for on-site installation in the sleeve. Different wound connections can be used both on the neck tube and in the sleeve. If the sleeve is suitable for the purpose for which it is intended, the thermometer can be installed using a movable connection on the neck tube. This means that thermometers with the same installation length as the inserts can be used variably, even if the length of the protection sleeve varies, they can be installed with the guarantee of achieving optimal thermal contact between the insert and the sleeve.

Measuring range

- From 200 to 600°C, for Pt sensors with wire wound (WW)
- From -50 to 500°C, for thin filmed (TF) Pt sensors

Operating characteristics

Working conditions Ambient temperature

Connection head	Temperature in °C	
Without transmitter	Aluminum head:	from -40 to 100° C
	Polyamide head:	from -40 to 85° C
With transmitter		from -40 to 85° C
With ceramic block		from -40 to 85° C

Process pressure

Maximum process pressure depends on the protection sleeve in which the thermometer is installed. The layout of the protection sleeve for welding-in is given in Figure 2, and the standard dimensions in Table 1. The pressure-temperature dependence is given in diagrams - Figure 3.

Permissible flow as a function of immersion length

Maximum permissible flow that the thermometer can withstand decreases with increasing immersion length of the protection sleeve in the flowing medium. In addition, it depends on the diameter and type of protection sleeve, the type of medium, temperature and pressure in the process. An overview of the sleeves that can be used is given on page _

Layout and dimensions of the protection sleeve according to DIN 43763 (Shape D1, D2, D4 and D5)

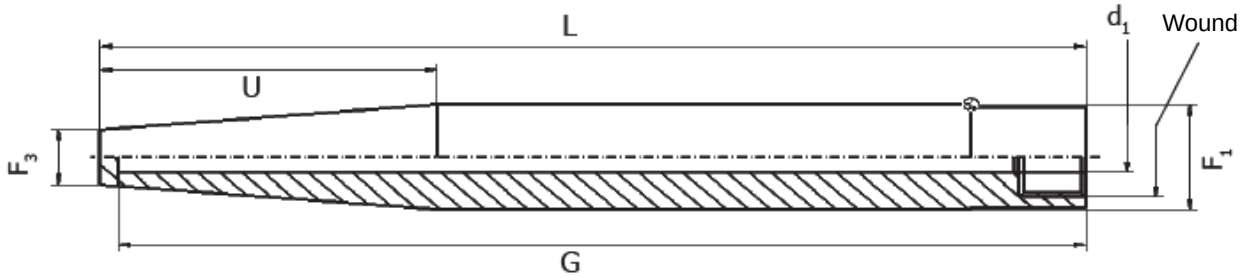
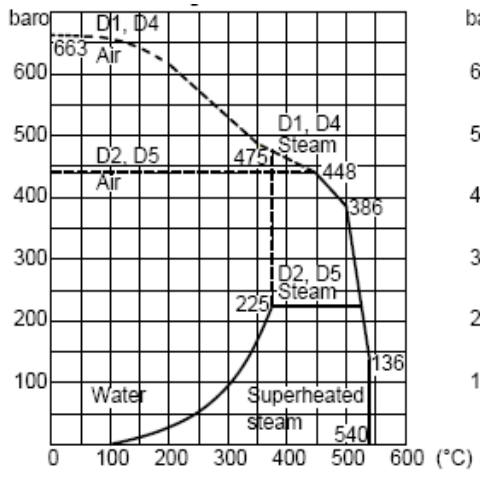


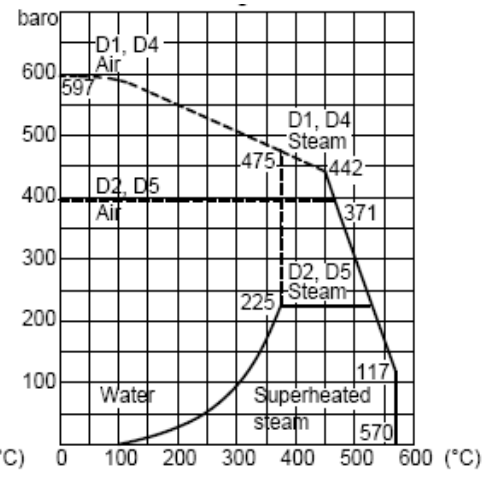
Figure 2 – Protection sleeve for welding-in

Table 1. Dimensions of standard protection sleeves

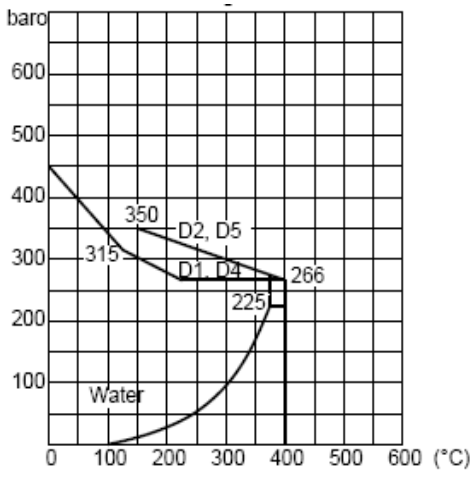
Shape according to DIN 43763	**Total length L (mm)**	**Cone length U (mm)**	**Depth G (mm)**	**Connection**	**F_1 / F_3 (mm)**	**Internal diameter d_1 (mm)**	**Measuring insert length (mm)**
D1	140	65	135	M18x1,5	F_1=24 h7 F_3=12,5	7	315
D4	200	65	195				375
D2	200	125	195				375
D5	260	125	255				435



For material: Č.7400
(W.Nr. 1.7335)



For material: Č. 7401
(W.Nr. 1.7380)



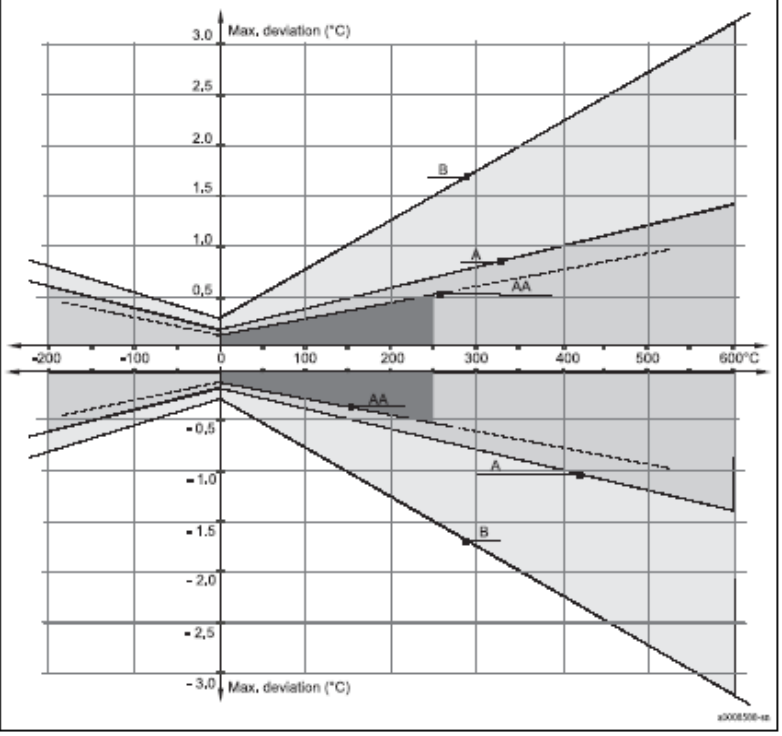
For material: Č.4574
(W.Nr. 1.4571)

Figure 3 -Diagrams: Pressure - temperature for protection sleeves for different sleeve materials

TERMOTEHNA can offer and deliver other shapes of protection sleeves, from B, C, E, F, G, according to DIN 43763 and/or GOST 28537, separately or in a set with a resistance thermometer.

Accuracy (certainty)
Given in Figure 4.
Sensor Pt 100 according to IEC 60751

Class	max. Tolerances (°C)	Temperature range	Characteristics
RTD max. error type TF - range: -50 to +400 °C			
Cl. A	± (0.15 + 0.002 · |t|[1)])	-50 °C to +250 °C	
Cl. AA, former 1/3 Cl. B	± (0.1 + 0.0017 · |t|[1)])	0 °C to +150 °C	
Cl. B	± (0.3 + 0.005 · |t|[1)])	-50 °C to +400 °C	
RTD max. error type WW - range: -200 to +600 °C			
Cl. A	± (0.15 + 0.002 · |t|[1)])	-200 °C to +600 °C	
Cl. AA, former 1/3 Cl. B	± (0.1 + 0.0017 · |t|[1)])	0 °C to +250 °C	
Cl. B	± (0.3 + 0.005 · |t|[1)])	-200 °C to +600 °C	



(1) |t|° absolute value in ° C

Figure 4- Accuracy classes of PT 100 sensors

Response time
Tests in water at a flow velocity of 0.4 m/s, according to IEC 60751, change step: 10 K.
Tested with measuring insert Pt 100 TF/WW

Insert diameter	**Response time**	
6 mm	T_{50} T_{90}	3,5 s 8 s
3 mm	T_{50} T_{90}	2 s 5 s

Insulation resistance
Insulation resistance is ≥ 100 M Ω at the room temperature.
Insulation resistance between each terminal and the sheath is checked at a test voltage of 100 V DC.

Self-heating
To measure the output signal of a resistance thermometer, current must pass through the sensor. This measuring current generates a power loss and thus produces heat on the sensor. As a result, the measured temperature is higher than it should be. This self-heating depends on several factors, and one of them is how far the generated power drop can be taken through the measuring device. Self-heating creates additional measurement errors. This error is negligible if a transmitter is built into the resistance thermometer.

Calibration

Termotehna, as a manufacturer of resistance thermometers, provides temperature calibration comparisons from -20 to + 600°C based on the International Temperature Scale (ITS90). Calibration can be monitored according to national and international standards. The calibration certificate corresponds to the serial number of the resistance thermometer.

Materials

Neck tube, measuring insert.

Temperatures listed in the following table are given only as reference values for the use of different materials in air and without significant pressure loading. The maximum operating temperatures are significantly reduced in some cases under abnormal conditions such as when a high mechanical load occurs or the temperature is measured in aggressive media.

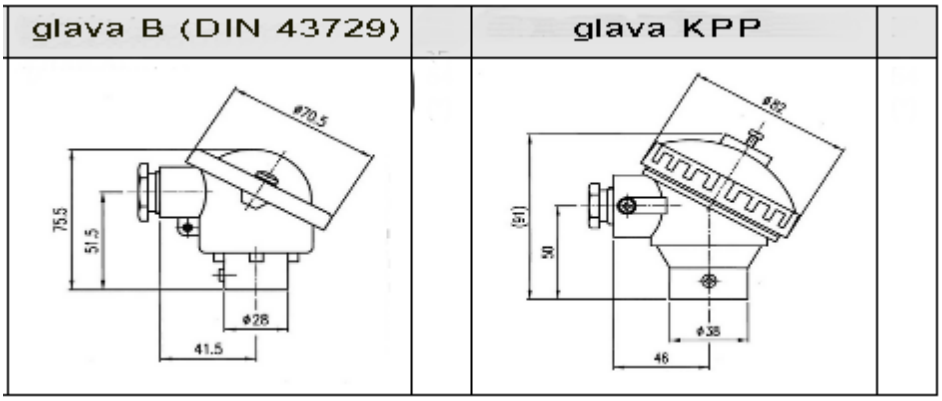
Material	Recommended max. temperature for continuous operation in air	Characteristics/Properties /Use
Č.4580 W.Nr.1.4301	700°C (in the air) 450°C in water or humid environment)	Resistant to corrosion. Use in the food industry where good corrosion resistance is required; Resistance to corrosion does not change even after welding the tube;
Č.4574 W.Nr. 1.4571	700°C	Addition of titanium increases resistance to pitting corrosion even after welding; A wide range of uses in the chemical, petrochemical and oil industries, as well as in coal processing; They can only be polished to a limited extent, marks may appear because of the titanium;
Inconel 600 2.4816	1100°C	A nickel/chromium alloy with very good resistance to aggressive, oxidizing and reducing atmospheres, even at high temperatures. Resistance to corrosion caused by chlorine gases and chlorinated environments, such as many oxidizing minerals, acids, seawater, etc.; Corrosion by distilled water; Not for use in atmospheres containing sulfur;

Constituent parts

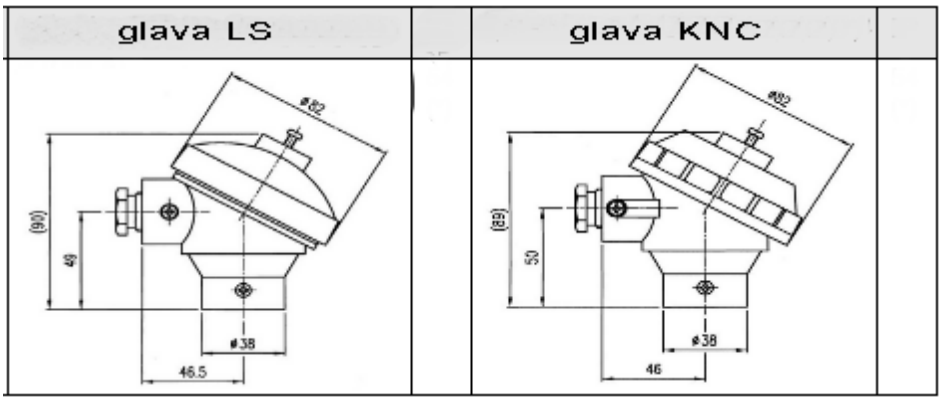
Connection heads

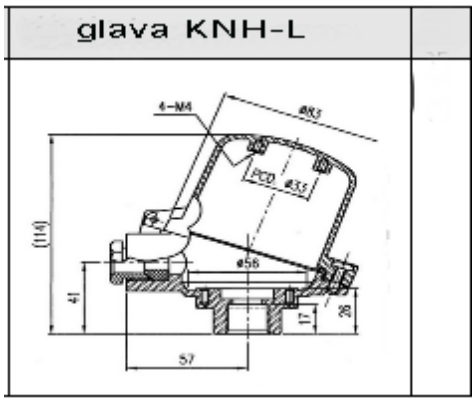
All connection heads have an internal shape and size in line with DIN 43729. The connection with the thermometer can be a connection M24x1.5, R1/2“, 1/2“NPT. Cable inlets are M20x1,5 R1/2“, 1/2“NPT. The following figures show the shapes of the connection heads. All measurements are in mm.

Head B (DIN 43728) / head KPP



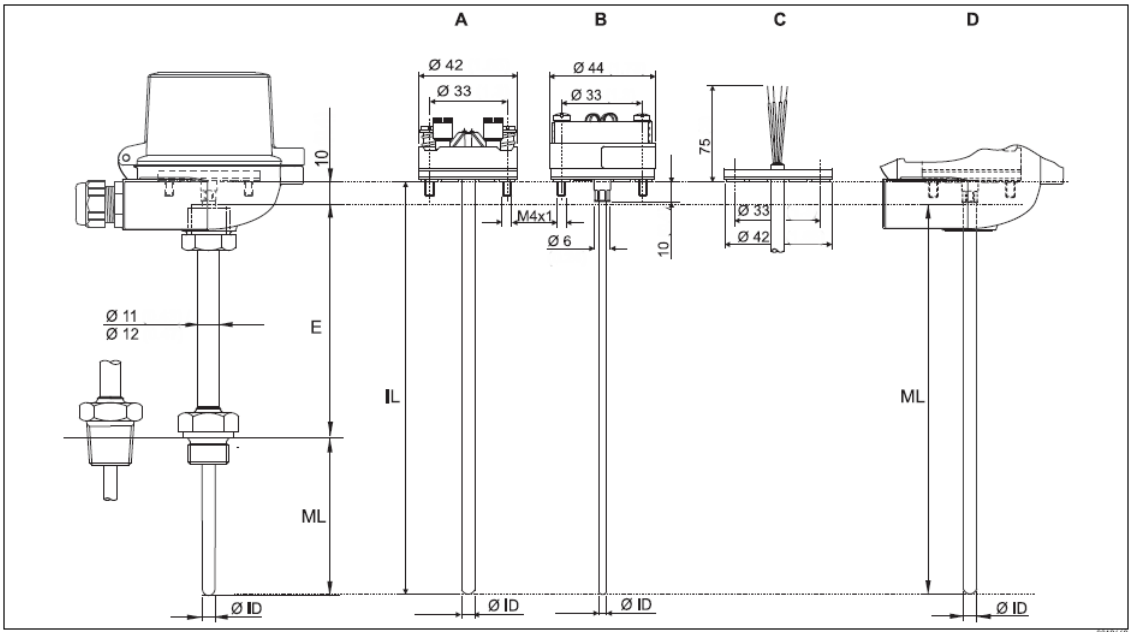
Head LS/head KNC





Head KNH-L

6



Structure All dimensions are in mm

A – Insert with ceramic block
B – Insert with transmitter
C – Insert with free outlet
D – Model without neck tube, prepared for installation in existing neck tube

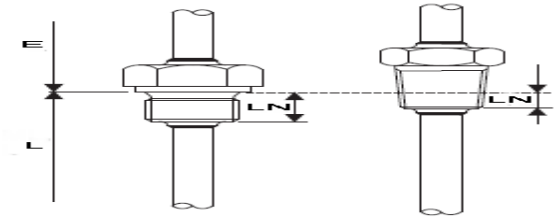
du – Insert diameter: 6 mm or 3 mm
Lv – Neck tube length
Lu – Measuring insert length=L+Lv+10

L – Nominal length

Weight
From 0.5 to 2.5 kg for standard designs

Process connection

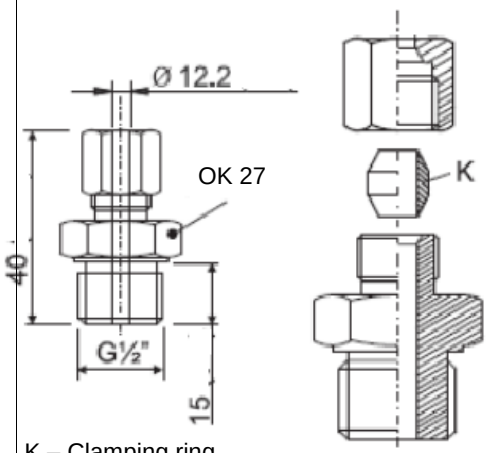
Thermometers are designed for installation in existing protection sleeves, which can be ordered separately. For installation, use the process connection on the neck tube.

Process connection		Design		Wound length LN in mm	OK
Cylindrical	Conical	M	M14 x 1,5	12	17
			M18 x 1,5		24
		G	G1/2“	15	27
		NPT	NPT 1/2“	8	22
		R	R 3/4“		27
			R 1/2“		2

E – Neck tube length

Movable connection (compression fitting)

Measuring insert is pushed through the connection, together with the neck tube Ø 11, and is secured by clamping the ring, made of stainless steel Č.4574. The ring cannot be reused. A new clamping ring must be provided for new use of the movable connector. The nominal length is adjustable by using movable connections.

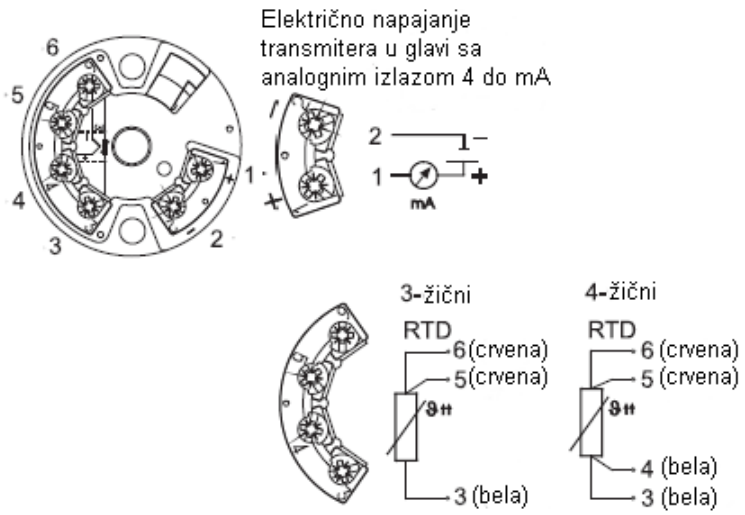
Process connection - compression fitting with wound	
	* It can be used for sleeves with a sufficiently large internal opening Ø >12 mm * It is used for processes where there is no pressure

K – Clamping ring

Wiring

Wiring diagrams ***Method of connecting the sensor***

Transmitter installed into the connection head (wiring for 1 x Pt 100)

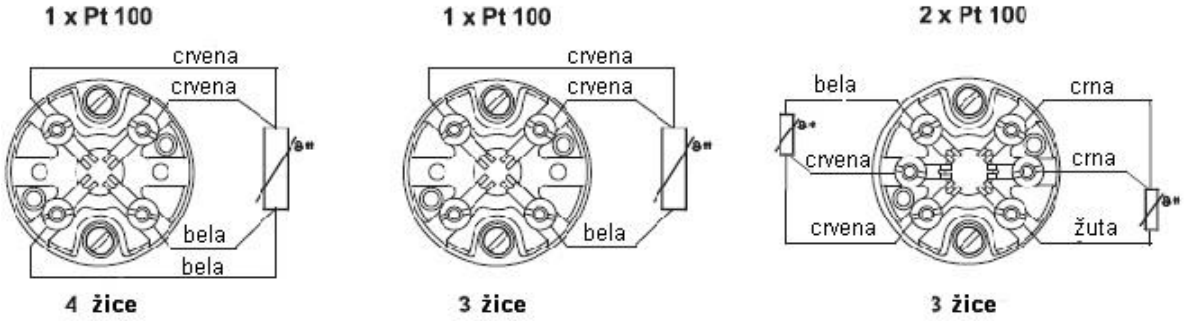


Power supply of the transmitter in the head with analog output 4 to mA
3-wire
6(red)/ 5 (red)/ 3 (white)
4-wire
6(red)/ 5 (red)/4 (white)/ 3 (white)

The following transmitters are applicable:

- PC programmable transmitters 4...20mA (galvanically isolated)
- Transmitters with HART protocol (galvanically isolated), the output contains 4...20mA and HART superimposed signals
- Transmitters (galvanically isolated) PROFIBUS PA with output signal, the communication address can be set via the appropriate software or by means of mechanical switches. Customer can request the desired configuration during the ordering process

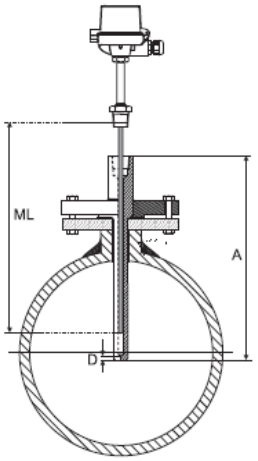
If the transmitters are installed on a DIN rail, ceramic blocks are installed in the connection head.
Ceramic block installed in the connection head



Installation

Orientation Not requested

Instructions for installation



Group T5- resistance thermometers are intended for installation in existing protection sleeves or in sleeves that can be ordered separately.

Connections of the sensor part with the sleeve are with different wounds, adapted to the wound on the sleeve and are installed on the neck tube.

Nominal length (ML) depends on the total sleeve length (A) and the type of sleeve used.

Length (ML) can be selected in the range from 100 to 5000mm. Longer lengths upon request.

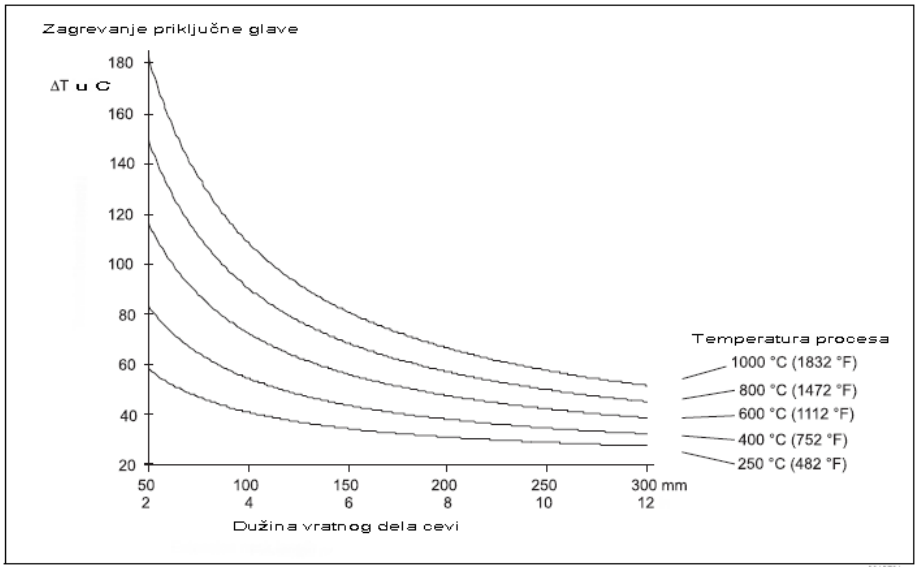
The same applies when ordering a measuring insert as a spare part.

It is recommended that the nominal length of ML be determined according to the formula:

ML = A - D + 3, where:
- A – sleeve length
- D – wall thickness at the top of the sleeve

Neck tube length

The neck part of the tube is the part between the connection and the connection head. As shown in the following figure, the length of the neck part of the tube has an effect on the temperature in the connection head. It is necessary that this temperature be within the limits specified in the Working conditions chapter.



Heating the connection head/Process temperature/Length of the neck part of the tube

Heating the connection head depends on the temperature in the process.
Neck tube diameter 11 or 12 mm

Certificates

- Calibration certificate for temperature measuring instruments

- Calibration certificate for temperature measuring equipment
- Certificate of calibration laboratory accreditation - accreditation no.: 02-058

Certificates

- Certificate for resistance thermometers and thermoelements for explosive atmospheres
- Ex label: Ex e II T4...T6 (Zone 1 i 2)
- Ex label: Ex e ia II CT4...T6 (Zone 0, 1 i 2)

Other details

Maintenance
Group T5 thermoelements do not require any special maintenance.

Periodic inspections are recommended because mechanical damage and thermal shocks, aggressive environments, and the occurrence of abrasion can cause sleeve damage.

Furthermore, calibration of thermocouples is recommended, once a year, by an authorized laboratory, in line with the Law.

Note: Protection sleeves are ordered separately, according to the table on page 4.

Table: *Thermovoltage values in [Ω] depending on temperature value*

	Resistance in [Ω]									
°C	0	10	20	30	40	50	60	70	80	90
- 200	18,49	14,45	10,49	6,99	4,26	2,51	-	-	-	-
- 100	60,25	56,19	52,11	48,00	43,87	39,71	35,53	31,32	27,08	22,80
- 0	100,00	96,09	92,16	88,22	84,27	80,31	76,33	72,33	68,33	64,30
0	100,00	103,90	107,79	111,67	115,54	119,40	123,24	127,07	130,89	134,70
100	138,50	142,29	146,06	149,82	153,58	157,31	161,04	164,76	168,46	172,16
200	175,84	179,51	183,17	186,82	190,45	194,07	197,69	201,29	204,88	208,45
300	212,02	215,57	219,12	222,65	226,17	229,67	233,17	236,65	240,13	243,59
400	247,04	250,48	253,90	257,32	260,72	264,11	267,49	270,86	274,22	277,56
500	280,90	284,22	287,53	290,83	294,11	297,39	300,65	303,91	307,15	310,38
600	313,59	316,80	319,99	323,18	326,35	329,51	332,66	335,79	338,92	342,03
700	345,13	348,22	351,30	354,37	357,42	360,47	363,50	366,52	369,53	372,52
800	375,51	378,48	381,45	384,40	387,34	390,26				

Catalog codes for standard Group T5 resistance thermometers

Temperature	Thermocouple	Nominal length L [mm]	Measuring insert length [mm]	Catalog number	
				1 thermocouple	2 thermocouples
up to 400^{0}C	Pt 100 in measuring insert fi 6, IEC 60751	140 200	315 375	T5-1411 T5-1412	T5-2411 T5-2412
up ot 540^{0}C	Pt 100 in measuring insert fi 6, IEC 60751	140 200	315 375	T5-1411.1 T5-1412.1	T5-2411.1 T5-2412.1